MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2015/2016

EOP4066 – OPTICAL COMMUNICATION SYSTEMS

(All sections/Groups)

17 OCTOBER 2015
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) Table 1 shows the characteristics of two types of fibers.

Table 1

Fiber Type	Fiber characteristics
Fiber A	- Only one mode of propagation - Core thickness is about 2-10 μm
Fiber B	- Can support a few propagation modes - Core thickness is about 50 μm

(i) Name the two types of fibers in Table 1. [2 marks]

(ii) Briefly describe ONE (1) advantage for each of the fiber types in Table 1. [2 marks]

(iii) Which of these two types of fibers suffers from modal dispersion? Justify your answer. [3 marks]

(iv) Which of these two types of fibers is suitable to be used in a long haul communication network? Justify your answer. [3 marks]

(b) Describe TWO (2) characteristics of a photodetector that makes it suitable for an optical fiber communication system. [4 marks]

(c) Figure 1 shows a fiber with a core refractive index of 1.505, a cladding refractive index of 1.475 and a core diameter of 25 μm. The fiber is surrounded by air.

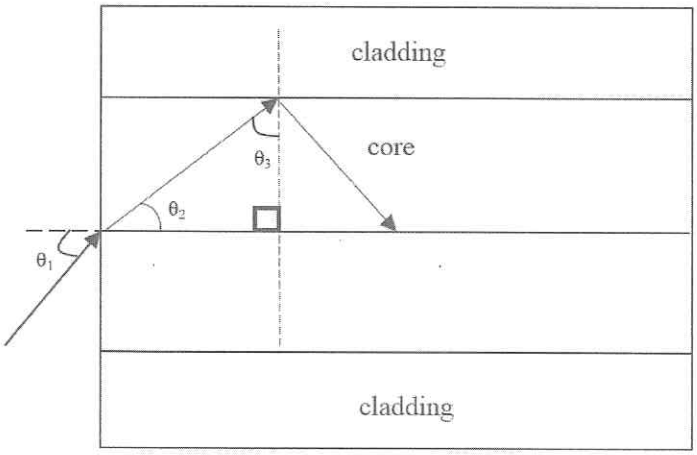

Figure 1

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Question 1 (25 marks) - Continued

(i) Calculate the numerical aperture and critical angle θ_3 of the fiber. Assume that the fiber is not bent. [4 marks]

(ii) Calculate minimum angle θ_1. [Hint: You may use Snell's Law.] [4 marks]

(iii) How many modes would propagate in the fiber at a wavelength of 1550 nm? [3 marks]

Question 2 (25 marks)

(a) Why is attenuation an important consideration in the design of optical transmission links? [2 marks]

(b) Two types of nonlinear scattering are stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS). A single mode fiber has a fiber core diameter of 10 μm at the operating wavelength λ of 1.55 μm, while using an injection laser source of bandwidth as 1.5 GHz. The attenuation α_{dB} is 0.2 dB/km. [Hint: Threshold power of SBS, $P_B = 4.4\times10^{-3}\ d^2\ \lambda^2\ \alpha_{dB}\ V$ (watt) and threshold power for SRS, $P_R = 5.9\times10^{-2}\ d^2\ \lambda\ \alpha_{dB}$ (watt)].

(i) Calculate the threshold power for both SBS and SRS. Comment on your answer. [5 marks]

(ii) Describe TWO (2) differences between SBS and SRS. [4 marks]

(c) Describe TWO (2) methods to reduce macrobending losses. [4 marks]

(d) An optical fiber has an attenuation (resulting from Rayleigh scattering) of 0.45 dB/km at a wavelength of 1.55 μm. Determine the Rayleigh scattering coefficient χ_R of the fiber. [3 marks]

(e) A 20 km optical fiber link consisting of a multimode step index fiber exhibits rms intermodal pulse broadening, $\sigma_{intermodal}$ of 280 ns and has a relative refractive index difference, Δ of 1%. [Hint: $\sigma_{intermodal} = \frac{Ln_1\Delta}{2\sqrt{3}\times c}$ where L is length of fiber and c is the speed of light]

(i) Estimate the core refractive index of the fiber, n_1. [2 marks]

(ii) Calculate the maximum bit rate that may be obtained assuming only intermodal dispersion. [2 marks]

(iii) Determine the maximum possible bandwidth on the link assuming RZ coding and the bandwidth-length product for the fiber. [3 marks]

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Question 3 (25 marks)

(a) As a network engineer, you are required to design an optical communication system for a wide bandwidth communication system. Propose the preferred optical fiber type and optical source for this network. For the preferred optical source, give TWO (2) reasons to support your answer. [6 marks]

(b) Describe TWO (2) differences between a semiconductor laser amplifier and a fiber amplifier. [4 marks]

(c) An optical amplifier has the parameter values as shown in Table 3. Calculate the input signal power (in dBm) and the signal-to-noise ratio (in dB) at the amplifier input. [4 marks]

Table 3

Symbol	Parameter	Value
λ	Wavelength	1.55 μm
P_{out}	Output power	20 mW
F	Noise figure	4
G	Gain	25 dB
n_{sp}	spontaneous-emission factor	2
Δv_{opt}	Optical bandwidth	25×10^{11} Hz
SNR_{output}	Signal-to-noise ratio at output	35 dB

(d) Describe the node connection of a star network and a ring network. Your answer should include how messages are transmitted from node to node. Which is the best among these two topologies? Justify your answer. [6 marks]

(e) With the help of a suitable diagram, illustrate and describe the concept of a basic add-drop multiplexed network. Assume there are five end users in the network. [5 marks]

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Question 4 (25 marks)

(a) Wavelength division multiplexing (WDM) is a technique that allows multiple channels to be carried in a single optical fiber. As an optical network engineer, propose an optical source, multiplexer and demultiplexer that is suitable for a WDM network and justify your answer. [9 marks]

(b) One of the nonlinear effects in a WDM system is due to four wave mixing (FWM).

(i) Name two factors that influence FWM. [2 marks]

(ii) Suggest ONE (1) method to minimize the impact of FWM. [2 marks]

(c) Two types of digital modulation scheme are non-return-to-zero (NRZ) and return-to-zero (RZ).

(i) Describe these two modulation schemes in terms of the power in a transmit "1" pulse and the bit period. [4 marks]

(ii) Which digital modulation scheme is mainly used in long distance submarine systems? Give ONE (1) reason for this. [3 marks]

(iii) Why does conventional NRZ and RZ system use low intensity pulses? [2 marks]

(d) A Mach Zehnder modulator has two arms made of an electro-optic material. Describe how intensity modulation is created using this type of modulator. [3 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

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